**DRAFT PLAN FOR RESEARCH IN**

# RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS END USE EFFICIENCY

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# RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS END USE EFFICIENCY

**TABLE OF CONTENTS**

## Section 1
## Introduction

***PIER Program***

On September 23, 1996, Governor Pete Wilson signed into law legislation (AB 1890) de-regulating California's electricity industry. With regard to energy-related research, development and demonstration activities, AB 1890 requires the California Energy Commission (Commission) to fund certain public interest RD&D that will advance science or technology not adequately provided by the competitive and regulated markets. The Commission has since established a "Public Interest Research Program" (PIER) and has documented the program mission, focus areas, and governance plan in a document entitled "Strategic Plan for Implementing the RD&D Provisions of AB 1890" (Commission Publication P500-97-007).

***Stage 1***

Stage 1 planning and implementation included the development of PIER policy goals and objectives and the subsequent general solicitations.

Through the Stage 1 planning process the following policy goals were developed :

1. Improve energy cost/value of California's electricity
2. Improve environmental and public health costs/risk of California's electricity
3. Improve reliability/quality of California's electricity
4. Improve safety of California's electricity
5. Maximize market/economy connection

In the first quarter of 1998, the Commission funded "transition" projects to support public interest RD&D previously conducted by investor-owned utilities prior to the onset of electric industry restructuring. In the 2nd and 3rd quarters of 1998, the Commission released general solicitations that included a request for proposal in the end-use efficiency area. While the solicitation was based on specific focus group input, the goals presented in the solicitation were broad. When the projects for this solicitation are approved and awarded, Stage 1 of PIER will be completed.

***Stage 2***

Stage 2 planning includes the development of specific program issues and goals, and strategies for meeting these goals. For Stage 2, the PIER Program has been divided into six programmatic areas (Buildings; Industrial/Ag/Water; Environmentally Preferred Advanced Generation; Renewables; Environmental; and Strategic). This document summarizes the Stage 2 planning efforts for the Buildings Program area.

The Buildings Program area includes new and existing buildings in both the residential and non-residential sectors. The Program seeks to decrease building energy use through research in improved building performance evaluation methods, and development and improvement of building energy practices, strategies, tools, and technologies. To ensure that the research results are adopted in the marketplace, the program also seeks to work closely with utilities, industry, and State energy efficiency programs to improve understanding in market functioning and implement research which reflects knowledge of customer behavior and market functioning. Stage 2 will provide more focus to research in each of the program areas through the identification of specific problems or issues. The program plans do not direct the technologies appropriate for research, but may provide technology examples for putting the issues in context. The intent is for the research community to identify the best solutions to address the issues. For the Buildings Program Area, the following issues have been identified:

- **Issue 1. Energy consumption is increasing in hotter, inland areas as new building construction increases in these areas.**

Building loads and energy consumption for lighting, air conditioning, and other equipment, particularly during peak periods, can lead to system outages. Research is needed to investigate energy efficiency, load shifting, distributed generation, and real-time energy consumption information options in both new and existing buildings.
*This issue relates to Policy Goal #1 and will address the reduction of electricity usage costs in cooling buildings, an increasing area of electricity use in California. Goals and objectives developed for this issue will focus on reducing and/or managing loads related to cooling buildings.*

- **Issue 2. Development of energy efficient products and services does not adequately consider non-energy benefits, such as comfort, productivity, durability, and decreased maintenance.**

Comfort and productivity are primary drivers in investment in energy efficient products or strategies. Understanding of the benefits and costs of energy efficiency, comfort and productivity is needed for both new and existing building applications to improve the design, adoption, and use of energy efficient products and strategies.
*This issue also relates to Policy Goal #1 and will address the reduction of electricity usage costs in buildings. Goals and objectives developed for this issue will focus on identifying and developing technologies, design methods, and strategies which simultaneously provide energy and non-energy benefits, thereby increasing their market acceptance.*

- **Issue 3. Building design, construction, and operation of energy features can affect public health and safety.**

Building construction, operation of ventilation systems, and certain building materials may contribute to moisture problems and indoor air pollution. Research is needed to construct new buildings and operate existing buildings in a manner that is both energy efficient and healthy.
*This issue relates to Policy Goals #2 and #4 and will address the reduction of health and safety issues related to buildings through the development of energy efficient technologies and strategies. Goals and objectives developed for this issue will focus on identifying and developing methods of mitigating indoor air quality and building moisture issues in buildings.*

- **Issue 4.  Investment in energy efficiency affects building and housing affordability and value, and the state's economy.**

Research is needed to develop new energy-efficient technologies, including currently undefined innovative advancements, which improve housing and non-residential building affordability and value through energy efficiency.  Additionally, optimization of buildings and equipment to be responsive to California climates and development of improved construction techniques and tools are needed to reduce costs associated with the construction of new buildings and operation of existing buildings.
*This issue relates to Policy Goals #1 and #5 and will address the opportunities to increase building value and affordability through the development of energy efficient building products and strategies.  Goals and objectives developed for this issue will focus on developing tools for energy efficient design and construction, building performance evaluation methods, developing cost-effective technologies, and optimizing systems design strategies.*

In all four issues, maximizing market connectedness (Policy Goal #5) is a common goal. This will be accomplished through targeting research on technologies and building practices that are responsive to market needs or can motivate greater market demand for energy efficiency.  In some instances this may necessitate first developing a better understanding of market performance characteristics and market motivations.

### *Electrical Consumption Data for Buildings*

- **Aggregated Consumption Data**

Consumption of electricity in California is steadily increasing each year. Between 1980 and 1993 California's electrical consumption rose 29%, from 157,439 GWh in 1980 to 222,806 GWh in 1993. This increase in electrical consumption is directly related to California's economic and demographic growth. During the same period California's Gross State Product increased 61%, (not adjusting for inflation), and total population rose 32.5%, from 23.8 million to 31.5 million (California Statistical Abstract, 1997).

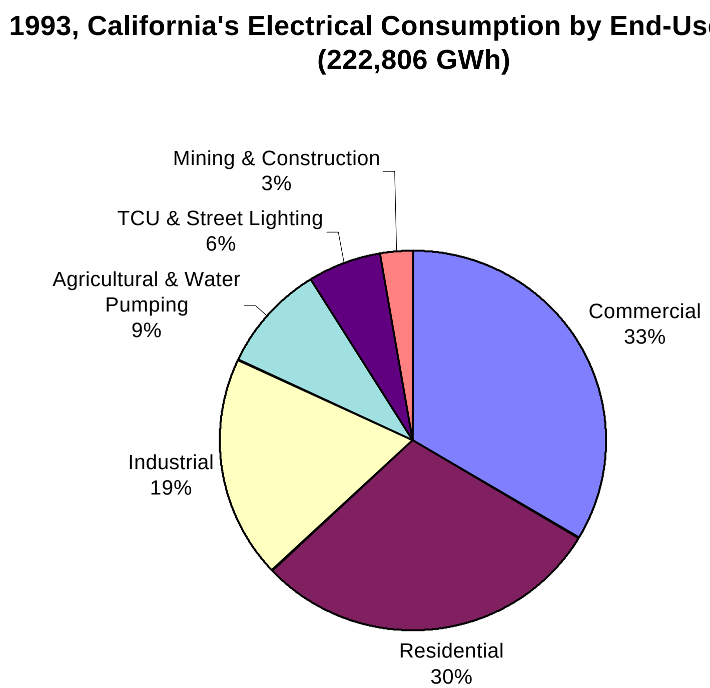


***Figure 1.1***

Figure 1.1 shows the breakdown of aggregated electrical consumption in California by end-use sector. The building sector, (residential and non-residential), consumed approximately 63% of the state's electricity in 1993. The industrial sector consumed 19%, and the agricultural
and water use sector consumed 9% of the state's electricity in 1993. The remaining sectors, transportation, communication, utilities and street lighting (TCU), and the mining/construction sectors combined consumed 9% of the state's electricity in 1993.

- **Residential Consumption Data**

The residential sector includes 11 end-use categories. The two categories that show the most intensive energy use are miscellaneous (28%) and refrigeration/freezer (24%) (CED, 1995). The miscellaneous category includes multiple end-uses, including lighting. Lighting is
estimated to be between 10% to 14% of the residential sector's total consumption, totaling between 6020 GWh and 9031 GWh in 1993. Electrical consumption is fairly evenly distributed among the other end-use categories. Figure 1.2 (on next page) illustrates the share of electrical consumption of these 11 residential end-use categories for California in 1993.

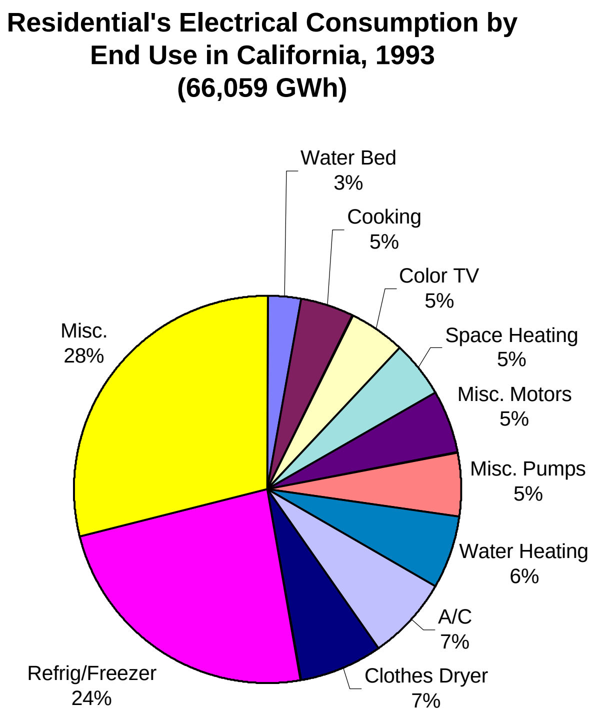


***Figure 1.2***

The data shown represents statewide consumption averages and does not address specific end uses which may be more intensive in certain areas of the state. For example, statewide cooling energy use is only 7% but may be considerably greater in the California valley and desert areas. The largest overall consumer of electricity is the miscellaneous category, but this category is the most diverse. Miscellaneous includes all plug loads that do not fit into the other categories, such as hair dryers, video-game systems, and lighting. Understanding the details of consumption in this category, the role lighting plays in energy consumption, and how to increase energy efficiency within this category is a promising RD&D opportunity.

## • Commercial Consumption Data

The commercial sector includes 8 end-use technologies. Figure 1.3 illustrates electrical consumption by end-use for 1993. Lighting is the biggest end use, with 42% of the sector's electrical consumption. The other big end uses were miscellaneous/office equipment (21%), space cooling (16%), ventilation (10%), and refrigeration (8%) (CED, 1995).

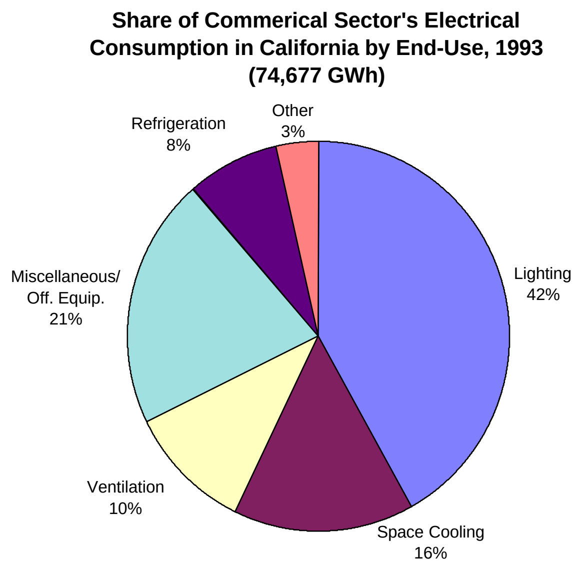


***Figure 1.3***

Lighting, miscellaneous/office equipment, and space cooling are end-use sectors that consume the most electricity per square foot of the sector's floor space. The miscellaneous/office equipment end-use category has experienced a notable increase in energy use; although this sector consumes a relative small amount of electricity per square foot, the ratio almost doubled between 1980 and 1993. RD&D that reduces this rate of growth could be promising. Like the residential sector, understanding the details of consumption of this category and how to curb its growth is a promising RD&D opportunity.

## Section 2
## FACT SHEET ON ISSUES FOR RESEARCH IN RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS END USE EFFICIENCY

**Issue 1. Energy consumption is increasing in hotter, inland areas as new building construction increases in these areas**.

***Background***

- The inland counties currently comprise about 30% of the state's population.[1] Between 1998 and 2015 the total population of the inland counties is projected to increase an average of 2% per year. By 2015, the inland counties will comprise 34% of the state's population. In comparison, the population of the coastal/transitional counties currently comprises about 68% of the state's population. Between 1998 and 2015, the population is projected to increase an average of 1% per year and overall will be reduced to 64% of the state's population. Population in the mountain regions will remain constant at 1.7% of the total state population.[2,3]

- Residential building permits rose 7.2% in the inland areas of the state from 1996-1997 as opposed to the coastal/transitional areas, which rose 4.9%, and the mountain areas, which declined 13.2% in the same time period. Based on the significant increases in housing costs in the Bay area, this trend can be expected to continue in upcoming years.[4]

- Statewide, 80,000 new homes were built in 1997, a large percentage in the inland climate zones. If 30% of these homes are equipped with central air conditioning, this will result in approximately 88MW of connected load growth. Since peak demand of conventional air conditioning technologies increases by approximately 16% as temperatures rise above 100 degrees F, this new load could result in 102MW peak load increase.[5]

***Discussion***

High value opportunities for PIER to address this issue include the following:

1. **Developing information to further understand this issue and identify highest value opportunities to mitigate it.** In particular, additional information is needed to better understand the probable system impacts of this increased energy consumption, how energy efficiency decisions will be made in a competitive marketplace, and market functioning as it relates to adoption and use of energy efficient products and services. Research in this area will help to further define PIER priorities for this issue.
2. **Developing strategies and technologies to reduce loads.** In addition to improving the efficiency of vapor compression cooling equipment, there are opportunities to reduce peak electrical loads through research in alternatives to compressor cooling, improvements to HVAC distribution system designs and materials, and better envelope construction strategies. Research in more efficient equipment and lighting, which contributes to the internal heat gains in a building, are also opportunities to reduce overall building loads. In addition, research into retrofit technologies and practices that can be applied through normal operation, maintenance, or modification provide opportunities to reduce the overall impact of projected growth in the building stock.
3. **Developing strategies and technologies to manage loads.** Opportunities for research in load management include developing smart metering technologies which provide consumers with

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[1] For this discussion, inland counties are defined as those with annual cooling degree days greater than 1200

[2] State of California: Department of Finance. California Statistical Abstract 1997. January 1997. Supplemental information for 1997 provided by CEC staff.

[3] State of California: Department of Finance. Projected Total Population of California Counties. May 1993.

[4] State of California: Department of Finance. California Statistical Abstract 1998. January 1998

[5] California Utility Research Council Letter to David A. Rohy, dated September 30, 1998

real-time feedback on energy use and associated costs, other load shifting options, thermal storage options, and energy efficient designs compatible with distributed generation opportunities.

**Issue 2. Development of energy efficient products and services does not adequately consider non-energy benefits, such as comfort and productivity.**

***Background***

- Comfort, productivity and other non-energy benefits are key drivers in decision making related to buildings. Comfort and productivity are driven by factors including temperature, humidity, lighting, ventilation, and air quality. Many of these factors are closely related to energy use in a building.

- It is believed that increasing productivity through energy efficient strategies (in both new and retrofit applications) will result in a manyfold increase in dollar savings. In one recent case study, an energy efficient lighting system was designed to replace old, inefficient lighting at a mail sorting station. The cost of the lighting retrofit was $300,000, resulting in $52,000 in annual energy and maintenance cost savings. Moreover, according to this study, worker output increased by 6%, errors decreased and savings potential was estimated at $400k to $500k per year from the productivity gains.[6]

- The potential for annual cost savings from increased productivity due to changes in lighting and thermal environment alone has been estimated at $12-$125 Billion in the U.S. Energy efficiency measures, which have a direct connection to productivity and/or comfort, include lighting, outside air economizers, heat recovery systems, nighttime pre-cooling, energy efficient building envelopes and energy efficient windows.[7]

***Discussion***

High value opportunities for PIER to address this issue include the following:

1. **Developing information to further understand this issue and identify highest value opportunities to mitigate it.** There is a gap in knowledge regarding how, and to what extent, comfort, productivity, and other non-energy benefits drive decisions relating to investments in energy efficiency. In addition, research is needed to better understand what energy technologies and strategies need to be developed (or modified) to be positively responsive to the relationship between these technologies and worker productivity. This understanding would build demand amongst building owners and energy managers for technologies and strategies which save energy and increase worker productivity.
2. **Developing metrics to quantitatively predict and measure non-energy benefits.** In residential buildings, metrics that quantitatively predict and measure the relationship between comfort and energy efficiency would help designers and manufacturers create energy efficient designs and products responsive to homeowner priorities. Similarly, for non-residential buildings, metrics would enable designers and manufacturers to create energy efficient designs and products that are responsive to worker productivity needs, and decreased operation and maintenance costs.
3. **Developing technologies which are both energy efficient and provide non-energy benefits**. Opportunities for research in technologies which consider both energy and productivity include lighting and daylighting options. Opportunities for research which account for both energy efficiency and comfort (which also impacts productivity) include climate adaptive envelope components and localized ventilation and temperature control of HVAC systems.
4. **Develop design methods, construction techniques, and strategies which address both energy efficiency and non-energy benefits**. Opportunities for research in strategies and

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[6] Romm, Joseph 1994. "Greening the Building and the Bottom Line: Increasing Productivity Through EE Design"

[7] Fisk, William J. 1998. "Potential Nationwide Improvements in Productivity and Health from Better Indoor Environments.", 1998 ACEEE Summer Study on Energy Efficiency in Buildings

construction techniques which consider both energy and non-energy benefits include developing methods to optimize building design; developing methods to evaluate building system performance which values non energy benefits; developing methods to incorporate maintenance costs, durability and reliability into ratings of energy efficient products; and developing design strategies for optimal duct placement.

**Issue 3. Building design, construction, and operation of energy features can affect public health and safety.**

***Background***

Indoor air quality (IAQ) is an issue for both residential and nonresidential buildings. Impurities including harmful bacteria, dust, CO2, CO, volatile organic compounds, molds and mildew, and combustion by-products can contribute to health problems. Health effects caused by poor indoor air quality have led to problems known as Sick Building Syndrome (SBS). Symptoms which characterize SBS include irritation of the eyes, nose and throat; dry mucous membranes and skin; mental fatigue and headache; respiratory problems; nausea; and dizziness. *Because symptoms are relieved when the employee leaves the building and may be reduced or eliminated by modifying the ventilation systems, this issue is closely tied to the energy use in buildings.* Tight buildings with controlled ventilation and energy recovery provide the greatest opportunity for comfort, economy, and health improvement.

- In one telephone survey of 600 office workers nationally, 24% reported that they were dissatisfied with the air quality in the office and 20% believed their performance to be hampered by poor indoor air quality.[8]
- In 1995, 22% of California schools reported indoor air quality problems. Indoor air quality problems are the most common complaint made to the California Dept. of Education [9]
- The building industry is experiencing an increasing number of construction defect litigation suits, which are triggered by occupant complaints, including those related to comfort problems. Lack of quality construction of energy efficiency features can lead to comfort problems and can also contribute to moisture-induced degradation and less healthy living environments through reduced indoor air quality.

***Discussion***

High value opportunities for PIER to address this issue include the following:

1. **Developing information to further understand this issue and identify highest value opportunities to mitigate it.** There is a gap in knowledge regarding how, and to what extent, current energy efficient design and construction practices affect health and safety in buildings. In addition, research is needed to better understand what energy technologies need to be developed (or modified) to be positively responsive to energy related health and safety issues in buildings. This understanding would lead to better design and construction methods and will help to further define PIER priorities for this issue.
2. **Developing metrics, sensors, and controls to measure and improve health, safety, and energy use in buildings.** In particular, better tools are needed to prevent, monitor, and control moisture and indoor air quality problems in buildings related to energy use. Better tools will enable homeowners and building energy managers to measure and control health and safety problems in buildings.
3. **Developing technologies and strategies that improve energy efficiency and enhance health and safety in buildings.** Research is needed to identify and develop the most effective technologies and strategies for mitigating IAQ and moisture problems through strategies compatible with energy efficient design and construction.

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[8] OSHA Federal Register: Indoor Air Quality - 59:15968-16039

[9] Daisey, Joan 1998. "Survey and Critical Review of the Literature on Indoor Air Quality, Ventilation and Health Symptoms in Schools"

**Issue 4. Investment in energy efficiency affects building and housing affordability, value, and the state's economy.**

***Background***

- Building affordability can be increased as a result of the inclusion of energy efficiency measures. Energy efficient financing is now available from many lenders which allow potential homeowners to increase the loan amount for a home. This increase is based on the fact that energy efficient homes result in lower utility bills and, therefore, borrowers have a larger proportion of their earnings available for monthly mortgage payments.
- Secondary lenders (Fannie Mae, Freddie Mac, FHA) have recognized that investment in energy efficiency in residences raises property values. These organizations authorize real estate appraisers to value energy efficiency improvements at the present value of the resulting energy savings up to the cost of the improvements.
- For commercial real estate, property value is a function of net income. Reduced energy costs increase net income and hence property value. Return on investment (profit), a function of property value, also increases. Investment in energy efficiency also can reduce the cash equity requirement for a real estate project; investment in energy efficient improvements can result in increased property value (beyond the cost of the improvement), increased loan amounts, and decreased cash equity requirements. [10]
- Construction quality improvements in energy related building components could play a significant role in reducing defect litigation and, therefore, reducing overall building costs associated with construction defect litigation.

***Discussion***

High value opportunities for PIER to address this issue include the following:

1. ***Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue.*** Research is needed to better understand consumer usage patterns relating to energy consuming products (HVAC, lighting, water heating) and identify future research opportunities to mitigate the problems. Further, a broader understanding of socioeconomic considerations that affect innovation, technology adoption, and market functioning would be useful to defining highest value future research. In addition, better understanding problems in implementation of building energy standards, including installation quality, is needed to develop more effective future building standards.
2. ***Develop software tools to improve energy efficient building design and implementation.*** Development of simplified design tools customized to California climates and compliance tools which include quality of construction benefits are needed to enable designers to create energy efficient buildings which are compatible with standard design tools, and cost effective California construction practices. In addition, energy simulation models which accurately assess equipment performance in California will facilitate the design and specification of space conditioning systems in buildings.
3. ***Develop energy efficient technologies to increase building value.*** Development of new, cost effective energy efficient technologies can further increase building value for both residential and non-residential applications. Opportunities include the development of advanced wall systems compatible with current California construction practices; downsized appliances to match reduced building loads for multi-family applications; development of energy efficient products and strategies for retrofit applications; and improved equipment functionality.
4. ***Develop strategies and tools to verify performance and establish value of investment.*** Building energy performance evaluation is critical to maximizing future building performance. Research to develop improved tools and methods to commission new buildings and re-commission existing buildings is needed to more effectively evaluate building energy performance in the non-residential sector. Standardized, user-friendly, protocols, specifications, and diagnostic tools for testing are needed for verification of energy performance in residences (verify energy performance, workmanship, IAQ). For both residential and non-residential buildings, tools and

[10] Hafter, Eric L. 1996 "Commercial Development Methods and Motivation"

techniques for verifying installed insulation quality, envelope sealing, and duct sealing are needed to assess the effectiveness of specific construction practices.

5. ***Develop systems approaches to maximize value through synergistic building and equipment designs.*** A broader systems approach to building energy design and construction needs to be developed to maximize the value of synergisms between various building components. In addition, research is needed to maximize the effectiveness of building components through the development of multi-functional appliances (HVAC/water heating, refrigeration, cooking).

## Section 3
## OVERALL GOALS FOR THE PIER RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS END USE EFFICIENCY Research Program

### *Long Term Vision - Year 2015*

The Buildings Program seeks to decrease building energy use through research in improved building performance evaluation methods, and development and improvement of building energy construction practices, strategies, tools, and technologies. To ensure that the research results are adopted in the marketplace, the program also seeks to work closely with utilities, industry, and State energy efficiency programs to improve understanding in market functioning and implement research which reflects knowledge of customer behavior and market functioning.

For commercial buildings, the long-term vision of the Buildings Program is to reduce the total average kWh/sf electrical consumption of commercial buildings by 25% (from 1996 levels). This reduction will be primarily manifested in the following end uses: lighting, office equipment, space cooling, ventilation and refrigeration. For residential buildings, the long term vision of the Buildings Program is to reduce total average kWh/capita/year electrical consumption in residential buildings by 25% (from 1996 levels). This reduction will be primarily manifested in the following end uses: lighting, space conditioning, and water heating.

The goal of 25% reduction in overall building energy use by 2015 translates to about 1.5% annually and is estimated to be achieved through energy use reductions in all new buildings (approximately one-third of the 25% reduction or .5% annually) and replacements in existing buildings (approximately two-thirds of the 25% reduction or 1% annually). This quantification of relative impact between new and existing buildings is a broad estimate. In a majority of the research that will be conducted, there will be direct applications in <u>both</u> the new and existing building markets and the penetration of research results will be highly dependent on market motivations. These goals are aggressive but potentially achievable.[11]

[11] In a typical year, new construction comprises approximately 2% of the total building stock and existing buildings comprise approximately 98% of the total building stock. For new buildings, energy efficiency measures are incorporated at the beginning of the life cycle of the building components (envelope, equipment, and appliances, etc.). A 25% reduction in energy use for new construction over the typical 1996 existing building stock appears reasonable. When this reduction (25%) is applied to new buildings (2% of the building stock), the overall impact is a .5% annual reduction in energy use intensity (.25x.02=.005 or .5%).

***General***

The PIER Buildings Program seeks to support research in new and existing non-residential and residential buildings which contributes to the design, construction, remodel, and operation of energy efficient buildings. Overall Program goals are:

1. Program is connected to the market, reflecting an understanding of market needs and market functioning. Buildings program customers and needs include the following:

    - Designers - develop tools needed to design energy efficiency in buildings and respond to owner needs.
    - Builders/Remodeling contractors - develop products and strategies which are consistent with California building practices and avoid construction defect and related problems.
    - Owners - develop products and strategies which are responsive to affordability, productivity, comfort and health and safety objectives.
    - Building managers - develop strategies and technologies which facilitates practical operation of the building to meet owners and occupants needs and objectives.
    - Occupants - produce buildings which have an affordable, productive, comfortable, safe, and healthy, energy efficient environment.
    - Manufacturers – respond to manufacturing constraints such as manufacturability, production costs, labor, and equipment needs.
    - CBEE - Coordinate with CBEE and others involved in market transformation activities to maximize market transfer of research results. Fund research that has a market perspective - identify and address impediments to getting technologies and strategies adopted.
    - Utilities - coordinate with utilities that are the administrators of public interest energy efficiency programs.

2. Program addresses highest value buildings research needs for California:

    - Program provides tangible benefits to California electric ratepayers by reducing energy costs (through improved energy efficiency and improved building practices), improved health and safety, and other indirect economic benefits.

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For existing buildings, changes are largely motivated by the end of the life cycle of a building component. Assuming typical life cycles for the various building components, replacements can be expected to occur in approximately 7.5% of the building components annually. A 15% energy efficiency improvement of replacement components over existing components appears reasonable for existing buildings. When applied over the 7.5% replacements, the overall impact of existing buildings is approximately a 1% annual reduction in energy use intensity. (.15x.98x.075=.01 or 1%).

Combined, an overall 1.5% annual energy use intensity reduction based on the development and use of new energy efficient technologies and practices appears achievable.

- Program advances to science or technology not adequately addressed by the competitive and regulated markets
- Program assesses status of research currently performed by other research entities to identify areas that PIER can have the greatest impact and ensure that PIER funded research is complementary to and not duplicative of work by others.
- Program conducts research in collaboration with other entities including utilities, universities, national laboratories, private industry, and others to build upon current knowledge and maximize opportunities for leveraging funding.
- Program collaborates with the California Board for Energy Efficiency (CBEE) where the research activity has both research and market transformation elements to ensure that high value synergistic research/market transformation opportunities are not lost.

3. Program is linked to the Commission’s Energy Efficiency Division’s new construction, market transformation, and building standards programs to maximize transfer of research results to the marketplace and increase overall program impact and value:

   Market transformation programs address the needs and issues of end-use energy consumers in both the residential and nonresidential sectors. The Commission’s market transformation programs address energy efficiency improvements in existing building stock as well as new construction. A major issue in all markets is that many efficient technologies are developed and available, yet consumers aren’t clamoring to use them. The construction industry is relatively slow to adopt new construction techniques and building technologies, even when these techniques or technologies offer superior performance or cost less when compared to conventional construction techniques or technologies. The industry is risk adverse and first-cost driven, and as a result has underutilized energy efficient construction materials and practices. This can be attributed to development fees which, the building industry reports, can be as high as $55,000 per unit.

   The current research and development activities of PIER will help change this situation through improvements in implementation of efficiency measures in these markets. For example, one project currently underway through PIER helps bridge information gaps through development and dissemination of performance specifications for the most efficient products. Several PIER research projects are also being done to help reduce first-costs of existing equipment and to improve reliability of equipment. Cheaper, more reliable versions of existing technology, made possible by advances in material science and manufacturing processes will improve cost effectiveness and will help gain consumer acceptance and increase market penetration of efficient products. In addition, PIER buildings research will include research to better understand how the building sector markets function. A better understanding of market functioning will lead to research focused on technologies and strategies the market will be receptive to.

   New construction and building standards programs at the Commission have also led to increased adoption of energy efficiency features in California’s building stock. However, while California buildings meet the energy efficiency standards in design, some do not, in practice, perform to the levels intended by the standards.

Advances in public interest science and technology often have a significant impact on the market through codes and standards.  Codes and standards depend on a strong technical basis for and characterization of materials and system performance.  The Commission's building energy standards (as well as home energy rating systems) depend both directly and indirectly on buildings systems R&D to form the technical basis for development of the standards.  The standards directly uses R&D results and also references industry standards and building codes that also rely on R&D results.

One example is the high duct leakage rates observed in both residential and non-residential construction.  Leakage rates of between 25 and 30% are common and can result in significant energy losses.  This is due, in part, to a need for better design tools, construction materials, and better quality construction.  Recent advances in the standards that recognize the actual performance of duct systems provide a basis for obtaining compliance credit for improved ducts, thus positively impacting the market for quality duct systems, and creating more options for builders.  R&D into duct performance created the knowledge base and technical underpinnings for these new improved code revisions.

Creation of the technical basis for codes, standards, and consumer labels (e.g. home energy rating systems) is one of the indispensable roles for research in the public interest.  The effort required for the development of codes and standards is reduced through the creation of a solid technical knowledge base that facilitates and minimizes technical debate.  All four technical issue areas can be positively impacted by research aimed at improvement of the technical basis for codes and standards.

In summary, the PIER Program will provide opportunities to research market factors which impact design and construction quality and to develop improved materials, methods, and tools for building design as well as improved quality construction practices in both new and retrofit applications.  Further, PIER research can identify opportunities for the building energy standards to serve not only as minimum compliance criteria, but also to stimulate market awareness and demand for energy efficient products and practices.

## DRAFT GOALS, OBJECTIVES, AND PERFORMANCE MEASUREMENTS FOR ISSUES IN THE RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS END USE EFFICIENCY Research Program

### Issue 1. Energy consumption is increasing in hotter, inland areas as new building construction increases in these areas.

***Performance Goal***

- **Reduce energy used for cooling new and existing buildings by 5% in five years, 10% in ten years, and 15% in fifteen years.**

***Technical Goals and Objectives***

- **Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue:**
    - Develop, on an ongoing basis, future program plans which reflect most current research needs.

- **Develop load reduction strategies and technologies**
    - Reduce cooling energy use in buildings through improvements/advancements in equipment, duct systems, alternatives to compressor cooling, envelope construction, lighting, and daylighting in both new and the operation, maintenance, or modification of existing buildings.

- **Develop load management strategies and technologies**
    - Increase consumer choices for load management
    - Increase options for customers to shift load to respond to time of use pricing
    - Create energy efficient design and construction strategies compatible with distributed heating, cooling, and power generation options

***Performance Measurements***[12]

- 10-30% reduction in lighting use (per capita) in the residential sector and (per square foot) in the non-residential sector from 1996 levels.
- 10-50% reduction in duct leakage losses from 1996 levels.
- 10-30% of new buildings exceed Title 24 by 20% due to incorporation of energy saving strategies or technologies not required by the energy standards, such as smart metering technologies, advanced envelope designs, natural ventilation, thermal storage, and construction quality improvements.
- 10-30% increase in efficiency of cooling and refrigeration equipment installed in residential and non-residential applications from 1996 levels.

[12] Performance measurements listed are initial estimates and should be considered only as a partial list of performance indicators. As the program progresses, other relevant performance measurements will be identified.

**Issue 2. Development of energy efficient products and services does not adequately consider non-energy benefits, such as comfort, productivity, durability, and decreased maintenance costs.**

***Performance Goal***

- **Increase energy efficiency in new and existing buildings by 3% in five years, 5% in ten years, and 8% in fifteen years through the development of energy efficient products and strategies which include non-energy benefits.**

***Technical Goals and Objectives***

- **Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue**
    - Develop, on an ongoing basis, future program plans which reflect most current research needs

- **Develop metrics to quantitatively predict and measure non-energy benefits such as durability, comfort, and productivity in energy related applications**
    - Enable designers, product developers, and product manufacturers to create energy efficient designs and products which account for non-energy benefits

- **Develop technologies which are both energy efficient and responsive to non-energy benefits**
    - Increase functionality and use of energy efficient products (lighting, daylighting, climate adaptive envelope components, localized HVAC controls) through integration of non-energy considerations.

- **Develop design methods, construction techniques, and strategies which address both energy efficiency and non-energy benefits**
    - Increase functionality and use of energy efficient designs (thermal distributions systems, daylighting, envelope design) through integration of non-energy considerations.

***Performance Measurements***[13]

- Increased development of energy efficient products or practices based on incorporation of non-energy benefits.
- 3-15% of new buildings are designed using design methods and software which accounts for both energy efficiency and non-energy benefits such as comfort and productivity.
- 3-15% of buildings incorporate energy efficient technologies and strategies in the new building design or existing building retrofit due to their non-energy benefits. Examples that influence productivity include efficient lighting and daylighting strategies, and energy efficient ventilation and temperature control options. Examples which increase comfort include advanced envelope technologies, envelope design strategies, and efficient temperature controls.

[13] Performance measurements listed are initial estimates and should be considered only as a partial list of performance indicators. As the program progresses, other relevant performance measurements will be identified.

## Issue 3. Building design, construction, and operation of energy features can affect public health and safety.

*Performance Goal*

- **Reduce building HVAC system energy consumption by 5% in five years, 10% in ten years, and 15% in fifteen years while simultaneously decreasing indoor air pollution and other health problems which impact energy use in buildings.**

### *Technical Goals and Objectives*

- **Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue**
  - Develop, on an ongoing basis, future program plans which reflect most current research needs
  - Determine which building features or construction practices related to energy efficiency can be modified to mitigate IAQ or moisture issues

- **Develop metrics, sensors and controls to measure and improve health, safety, and energy use in buildings.**
  - Enable designers, product developers, and product manufacturers to create designs and products which mitigate health and safety problems in buildings
  - Create options for sensing and controlling moisture and IAQ in buildings

- **Develop technologies and strategies to improve energy efficiency and enhance health and safety in buildings**
  - Improve ventilation design and building construction techniques which mitigate moisture and indoor air pollution

***Performance Measurements***[14]

- 5-15% of buildings use energy efficient ventilation strategies and technologies responsive to actual pollutant levels.
- 15%-30% improvement (from 1995 levels) in air quality for schools and offices through the development of energy efficient temperature and ventilation control technologies and strategies.
- 10-30% decrease in construction defect litigation in residences due to energy-related comfort or moisture problems.

## Issue 4. Investment in energy efficiency affects building and housing affordability and value, and the state's economy.

*Performance Goal*

- **Increase energy efficiency in new and existing buildings by 5% in five years, 10% in ten years, and 15% in fifteen years through the development of energy efficient technologies and strategies which increase building value.**

### *Technical Goals and Objectives*

- **Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue**
  - Develop, on an ongoing basis, future program plans which reflect most current research needs

- **Develop software tools to improve energy efficient product design and implementation**

[14] Performance measurements listed are initial estimates and should be considered only as a partial list of performance indicators. As the program progresses, other relevant performance measurements will be identified.

- Improve effectiveness of building energy standards through development of more accurate design and compliance tools
    - Improve HVAC performance and design through energy simulation software responsive to California climates
    - Improve energy efficient design through simplified design tools which are customized to California climates and includes building economics model, and/or is compatible with standard industry design tools such as computer aided design (CAD) systems.

- **Develop energy efficient technologies and strategies to increase building value**
    - Create opportunity for new innovations to improve building energy efficiency and affordability
    - Increase energy efficiency and value in existing buildings through identification and development of highest value strategies and technologies in retrofit applications
    - Increase building energy efficiency and value through the development of strategies responsive to current construction practices (including metal framing options)
    - Create downsized equipment to match reduced building loads in multi-family applications

- **Develop strategies and tools to verify performance and establish value of investment**
    - Increase building performance through development of better tools for verifying and monitoring energy performance of buildings (commissioning and diagnostic tools)
    - Increase performance of building components through development of tools for verifying installation quality of insulation, envelope sealing, and duct sealing

- **Develop systems approaches to maximize value through synergistic building and equipment designs**
    - Increase product value through the development of integrated, multi-functional appliances and equipment
    - Increase building functionality and decrease operational costs through development of design and construction strategies applicable to California climates
    - Increase value of energy efficient strategies and products through integration with other building elements

***Performance Measurements***[15]

- 10-30% increase in cost effective energy technology options for buildings from 1996 levels.
- 10-30% improvement in energy standards compliance rates from 1996 levels.
- 30-50% increase in number of non-residential buildings undergoing building commissioning procedures which ensures that the design intent of the energy features is carried into construction and operation of the building.
- 20-30% of new homes undergo building diagnostic procedures which optimize building performance.
- 5-20% of new buildings designed include systems design approaches.

[15] Performance measurements listed are initial estimates and should be considered only as a partial list of performance indicators. As the program progresses, other relevant performance measurements will be identified.

## Section 4
## PIER Buildings Contracts

| Contract # | Transition Contracts | Contract Amount |
|---|---|---|
| | | |
| 500-97-013 | Residential Thermal Distribution Systems | $ 400,000.00 |
| 500-97-013 | Commercial Thermal Distribution Systems | $ 400,000.00 |
| 500-97-013 | Alternative to Compressor Cooling | $ 350,000.00 |
| 500-97-013 | Diagnostics for Building Commissioning and Operations | $ 350,000.00 |
| 500-97-013 | Development and Demonstration of High Efficiency Lighting Torchieres | $ 90,000.00 |
| 500-97-013 | Building Design Advisor | $ 350,000.00 |
| 500-97-010 | Evaluate Small AC Units for Northern/Central California Climates | $ 500,000.00 |
| 500-97-010 | Improve Cost Effectiveness of Building Commissioning | $ 300,000.00 |
| 500-97-010 | Improve Cost Effectiveness of Building Control Systems | $ 250,000.00 |
| 500-97-010 | Food Service Technology Center | $ 350,000.00 |
| | **Subtotal - Transition Contracts** | **$ 3,340,000.00** |
| | | |
| | | |
| | **PIER2 Contracts** | |
| 500-98-020 | Energy Efficient Downlights for California Kitchens | $ 648,603.00 |
| 500-98-026 | HVAC Distribution Systems in Commercial Buildings | $ 537,000.00 |
| 500-98-032 | Next Generation Power Management User Interface for Office Equip. | $ 449,841.00 |
| 500-98-033 | Instrumented Home Energy Rating and Commissioning | $ 710,000.00 |
| 500-98-021 | Increased Energy Efficiency of Refrigerators and Air Conditioners | $ 411,614.00 |
| 500-98-029 | Removing Key Technical Barriers to...Use of Advanced Absorption Cooling | $ 690,178.00 |
| 500-98-022 | Development of an Advanced Indirect Heat Exchange Module | $ 248,719.00 |
| 500-98-024 | Alternative to Compressor Cooling - Phase IV | $ 713,246.00 |
| 500-98-023 | Conceptual Design Energy Analysis Tool | $ 452,655.00 |
| 500-98-025 | A Tool for Comprehensive Analysis of Low-Rise Residential Buildings | $ 216,190.00 |
| 500-98-027 | Building Specification Guidelines for Energy Efficiency | $ 233,280.00 |
| 500-98-028 | Design Refinement and Demonstration ...Res. Heat Pump Water Heater | $ 756,095.00 |
| 500-98-031 | Improve Energy Efficiency of Commercial Kitchen Exhaust Systems | $ 276,165.00 |
| 500-98-039 | Investigation of Secondary Loop Supermarket Refrigeration Systems | $ 300,000.00 |
| | **Subtotal - PIER2 Contracts** | **$ 6,643,586.00** |
| | | |
| | **TOTAL CURRENT BUILDINGS CONTRACTS** | **$ 9,983,586.00** |
| | | |

**PIER Transition Contract Summary**
**Contract End Date: September 30, 1999**
**Buildings Program Area**

| CONTRACT INFORMATION | **RELEVANCE TO STAGE 2 GOALS AND OBJECTIVES** (Appendix B - List of Issues, Goals, and Examples) |
|---|---|
| **Contract #:** 500-97-013<br>**Project Name:** Residential Thermal Distribution Systems<br>**Contract Amt:** $400,000<br>**Project Description:** This project continues CIEE's effort to develop new residential air duct knowledge and prototype technologies that would form the underlying scientific and technological basis of both short- and long-term products in both new construction and retrofit markets. | (I)2. Example bullets 4,7 - Addresses Issue 1 through the improvement of thermal distribution systems to reduce total building loads.<br>(IV)4. Example bullets 2,3 - Addresses Issue 4 through the development of diagnostic tools for verification of energy performance |
| **Contract #:** 500-97-013<br>**Project Name:** Commercial Thermal Distribution Systems<br>**Contract Amt:** $400,000<br>**Project Description:** The purpose of this project is to provide new technology and applications knowledge that will allow the construction and energy services industry to reduce energy waste in commercial thermal distribution systems. This project will do this through the implementation of aerosol technology for encapsulation, and by coordinating with sub-system technology efforts to create a system optimizing approach. | (I)2. Example bullet 7 - Addresses Issue 1 through the improvement of thermal distribution systems to reduce total building loads. |
| **Contract #:** 500-97-013<br>**Project Name:** Alternative to Compressor Cooling<br>**Contract Amt:** $350,000<br>**Project Description:** The purpose of this project is to develop and evaluate house designs capable of providing comfort in California's transition climates, without the use of conventional compressor-based cooling. | (I)2. Example bullets 10, 11 - Addresses Issue I through the development of natural ventilation strategies and envelope designs which minimize the need for compressor cooling.<br>(II)4. Example bullet 1 - Addresses Issue II through the development house designs that provide comfort in transition climates without the use of compressor based cooling.<br>(IV)5. Example bullet 1 - Addresses Issue IV through the development of a systems oriented envelope design approach. |

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| **Contract #:** 500-97-013<br>**Project Name:** Diagnostics for Building Commissioning and Operations<br>**Contract Amt:** $350,000<br>**Project Description:** The purpose of this project is to demonstrate an advanced operator information system for whole-building commissioning and operations. This system will include high quality sensors, a knowledge base to identify system failure, automated communications and data management, and data visualization to diagnose building energy performance problems. | (IV)4. Example bullet 1 - Addresses Issue IV through the demonstration of building commissioning strategies and benefits to validate value of commercial building commissioning. |
| **Contract #:** 500-97-013<br>**Project Name:** Development and Demonstration of High-Efficiency Lighting Torchieres<br>**Contract Amt:** $90,000<br>**Project Description:** The purpose of this project is to develop and test the next generation of electrodeless advanced T/18 tubular fluorescent lamps. This project will also develop portable, high-efficiency, indirect torchiere fixture that will use one of the next generation high-efficacy electrodeless fluorescent lamps. | (I)2. Example bullet 1 - Addresses Issue I through the development of efficient lighting to reduce overall building loads. |
| **Contract #:** 500-97-013<br>**Project Name:** Building Design Advisor<br>**Contract Amt:** $350,000<br>**Project Description:** The purpose of this project is to develop the Building Design Advisor, a Windows based software, that will facilitate decision-making with sophisticated analysis tools, from the initial schematic shapes of building design to make it much easier for decision maker to quantitatively assess the energy and non-energy implication of energy-efficient strategies and technologies. | (II)2. Example bullet 1 - Addresses Issue II through the development of software for commercial buildings that addresses both energy and non-energy benefits of EE technologies.<br>(IV)2. Example bullet 3 - Addresses Issue IV through the development of simplified software design tools to facilitate energy efficient design of buildings. The product developed will be used both in California and nationally. |
| **Contract #:** 500-97-010<br>**Project Name:** Evaluate Small Air Conditioning Units for Northern/Central California Climates<br>**Contract Amt:** $500,000<br>**Project Description:** This project will evaluate advanced, small commercial roof top package cooling system technologies for operation in California's hot dry climate. This project will enlarge PG&E's environmental chamber to handle HVAC package systems in the 5-to-10 ton range. | (I)2. Example bullet 3 - Addresses Issue I through the evaluation and improvement of HVAC equipment performance to reduce overall building loads.<br>(IV)3. Example bullet 8 - Addresses Issue IV through the improvement of HVAC performance to reduce overall operating costs. |

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| **Contract #:** 500-97-010<br>**Project Name:** Improve Cost Effectiveness of Building Commissioning Using New Techniques for Measurement, Verification and Analysis<br>**Contract Amt:** $300,000<br>**Project Description:** This project will investigate and demonstrate methods to reduce the cost of building commissioning and diagnosis. The ultimate goal is to create commissioning techniques that are more effective and less costly to implement. | (IV)4. Example bullet 1 - Addresses Issue IV through the evaluation of commercial building commissioning strategies and the identification of cost effective improvements to the commissioning process. |
| **Contract #:** 500-97-010<br>**Project Name:** Improve Cost Effectiveness of Building Control Systems<br>**Contract Amt:** $250,000<br>**Project Description:** This project will investigate solutions to the data acquisition and monitoring challenges faced when using energy management systems for advanced control, performance monitoring, diagnostics, and commissioning. This project will investigate lower cost sensors for monitoring, measuring and data acquisition, and the needs for data acquisition facilities within the control systems themselves. | (IV)4. Example bullet 1- Addresses Issue IV through the identification of cost effective data acquisition methods for verifying building energy performance. |
| **Contract #:** 500-97-010<br>**Project Name:** Food Service Technology Center<br>**Contract Amt:** $350,000<br>**Project Description:** This project will investigate ways to test and then reduce the release of cooking-related particles from the exhaust systems of commercial kitchens and minimize the amount of building energy use associated with the operation of such systems. This project will also increase the efficiency of commercial kitchen HVAC system as a way of reducing the energy associated with their operation. | |
| Total Transition Contract Funding: $3,340,000 | |

**PIER 2nd General Solicitation - Proposed Contracts**
**Buildings Program Area**

| PROPOSED CONTRACT | **RELEVANCE TO STAGE 2 GOALS AND OBJECTIVES** (See Appendix B - List of Issues,Goals, and Examples) |
|---|---|
| **Contract #:** 500-98-020<br>**Project Name:** Energy Efficient Downlights for California Kitchens<br>**Contract Amt:** $648,603<br>**Project Description:** The purpose of this project is to develop a single, dimming, electronic ballast that controls multiple CFL downlights. Thermoplastic fixtures with high efficiency reflective coatings will also be developed. These improvements will help overcome market barriers associated with CFL. Finally, this CFL technology will be demonstrated in the home construction industry. | (I)2. Example bullet 1- Addresses Issue I through the development of efficient lighting to reduce overall building loads. |
| **Contract #:** 500-98-026<br>**Project Name:** HVAC Distribution Systems in Commercial Buildings<br>**Contract Amt:** $537,000<br>**Project Description:** The purpose of this project is to provide the scientific knowledge needed to get improved air distribution systems into California commercial buildings. It includes field measurement before and after retrofits, development of diagnostic protocols, and development and evaluation of advanced sealing and coating retrofit technologies. | (I)2. Example bullet 7 - Addresses Issue 1 through the improvement of thermal distribution systems to reduce total building loads.<br>(IV)4. Example bullet 3 - Addresses Issue 4 through the development of diagnostic tools for verification of energy performance. |
| **Contract #:** 500-98-032<br>**Project Name:** Next-Generation Power Management User Interface for Office Equipment<br>**Contract Amt:** $449,841<br>**Project Description:** This project will assess the devices capable of power management and evaluate the terms, symbols, metaphors, and overall approaches to the user interface. LBNL will then propose and refine standard design principles for future power management controls, and work for adoption of these standards. | (IV)3. Example bullet 4 - Addresses Issue IV through the improvement in energy efficiency commercial office equipment.<br>(IV)5. Example bullet 1 - Addresses Issue IV through a systems approach to developing equipment systems. |
| **Contract #:** 500-98-033<br>**Project Name:** Instrumented Home Energy Rating and Commissioning<br>**Contract Amt:** $710,000<br>**Project Description:** The purpose of this project is to demonstrate the value of building commissioning services in both new and existing homes. A study will be done to determine what possible benefits can result from commissioning and recommended commissioning procedures guide will be developed. | (IV)4. Example bullets 2 - Addresses Issue 4 through the development of standardized tools for verification of energy performance. |

| PROPOSED CONTRACT | **RELEVANCE TO STAGE 2 GOALS AND OBJECTIVES** (See Appendix B - List of Issues,Goals, and Examples) |
|---|---|
| **Contract #:** 500-98-021<br>**Project Name:** Increased Energy Efficiency of Refrigerators and Air Conditioners<br>**Contract Amt:** $411,614<br>**Project Description:** This project will develop and test a power electronics/motor technology that will permit the use of lower-cost, more efficient, 3-phase power motors with single-phase power sources. This technology will be demonstrated in refrigerators, and is expected to improve energy efficiency (and other end-uses) by 19%. | (I)2. - Example bullets 3,8 - Addresses Issue I through the evaluation and improvement of HVAC and refrigeration equipment performance to reduce overall building loads. |
| **Contract #:** 500-98-029<br>**Project Name:** Removing the Key Technical Barriers to the Widespread Use of Advanced Absorption Cooling<br>**Contract Amt:** $690,178<br>**Project Description:** This project will develop and test a low-cost corrosion resistance material using diffusion metal coating on low-cost metals to reduce the cost of absorption cooling units. This will address the cost barriers associated with the market penetration of absorption cooling. Fabrication and manufacturing processes will also be identified. | (I)2. Example bullet 6 - Addresses Issue I through the improvement of absorption cooling performance to reduce overall building loads. |
| **Contract #:** 500-98-022<br>**Project Name:** Development of an Advanced Indirect Heat Exchange Module<br>**Contract Amt:** $248,719<br>**Project Description:** This project will design, develop and test an improved heat exchanger for the advanced indirect evaporative cooling stage of the SmartCool two-stage evaporative cooler. This indirect heat exchanger will lower the cost of the SmartCool unit by 70% and allow for a range of sizes. A manufacturing strategy will also be developed. | (I)2. Example bullet 10 - Addresses Issue I through the development of alternatives to compressor cooling. |
| **Contract #:** 500-98-024<br>**Project Name:** Alternative to Compressor Cooling: Phase V<br>**Contract Amt:** $713,246<br>**Project Description:** This project will develop a variable speed hydronic heating and ventilation cooling fan coil unit. This coil will be integrated into a heating, ventilation and cooling unit that will eliminate the need for compressor cooling in California's transition climates. Intelligent control systems for operation of the system will be developed, and the technology will be demonstrated in Climate Zones 3 and 12 to help determine building thermal performance and cooling system sizing issues, human interactions with controls, and builder/owner response to the new technology. | (I)2. Example bullet 10 - Addresses Issue I through the development of alternatives to compressor cooling.<br><br>(IV)5. Example bullet 1 - Addresses Issue IV through the development of a systems oriented equipment design approach. |

| PROPOSED CONTRACT | **RELEVANCE TO STAGE 2 GOALS AND OBJECTIVES** (See Appendix B - List of Issues,Goals, and Examples) |
|---|---|
| **Contract #:** 500-98-023<br>**Project Name:** Conceptual Design Energy Analysis Tool (CDEAT) R&D<br>**Contract Amt:** $452,655<br>**Project Description:** This project will develop an energy analysis software module to test the energy related impact of commercial buildings design, with the goal of reducing energy and demand consumption. The module is being developed to seamlessly integrated into Design Workshop, a 3-D modeling and rendering tool. | (IV)2. Example bullet 4 - Addresses Issue IV through the development of energy design tools compatible with graphical building design tools. |
| **Contract #:** 500-98-025<br>**Project Name:** A Tool for the Comprehensive Analysis of Low-Rise Residential Buildings<br>**Contract Amt:** $216,190<br>**Project Description:** This project will develop the user interface of a Windows based design and analysis tool for residential buildings using the DOE 2.2 calculation engine. The software will help homeowners, design professionals, and product/equipment manufacturers model all aspects of residential energy usage. | (IV)2. Example bullet 3 - Addresses Issue IV through the development of simplified software design tools to facilitate energy efficient design of buildings. The product developed will be used both in California and nationally. |
| **Contract #:** 500-98-027<br>**Project Name:** Building Specification Guidelines for Energy Efficiency<br>**Contract Amt:** $233,280<br>**Project Description:** This project will develop and publish energy efficient reference specifications for architects, engineers and lighting designers to select from and insert into their construction documents. This project will focus on the specification of components, systems and controls, with a strong emphasis on performance monitoring and commissioning of those systems. Emphasis will also be placed on architectural materials and the attributes that affect the life-cycle energy consumption of a building. | (IV)4. Example bullet 2 - Addresses Issue IV through the development of standardized specifications for the inclusion of energy efficient systems and performance evaluation in non-residential buildings |
| **Contract #:** 500-98-028<br>**Project Name:** Design Refinement and Demonstration of a Market-Optimized Residential Heat-Pump Water Heater (HPWH)<br>**Contract Amt:** $756,095<br>**Project Description:** The purpose of this project is to redesign the market-optimized HPWH to lower the equipment costs, and to make the HPWH system easier to install. Durability/reliability tests will be conducted, and the HPWH will be demonstrated to assess end-user acceptance and ease of installation. | (IV)3. Example bullet 1 - Addresses Issue IV through the improvement of advanced technologies to improve performance and reduce overall operating costs. |

| PROPOSED CONTRACT | **RELEVANCE TO STAGE 2 GOALS AND OBJECTIVES** (See Appendix B - List of Issues,Goals, and Examples) |
|---|---|
| **Contract #:** 500-98-031<br>**Project Name:** Improve Energy Efficiency of Commercial Kitchen Exhaust Systems<br>**Contract Amt:** $276,165<br>**Project Description:** This project will improve the energy efficiency of commercial kitchen exhaust systems through characterizing and optimizing the performance of makeup air strategies. This will reduce the HVAC load of commercial kitchens. Improved design guidelines will be drafted and published for the food service community. | |
| **Contract #:** 500-98-039<br>**Project Name:** Investigation of Secondary Loop Supermarket Refrigeration Systems<br>**Contract Amt:** $300,000<br>**Project Description:** This project will investigate improvement to secondary loop refrigeration systems, design and develop a maximized energy efficient system, and then demonstrate the system in two operating supermarkets. Current secondary loop refrigerators reduce the amount of ozone depleting refrigerants needed, but are usually more energy intensive than traditional refrigeration technologies. This project will overcome this market barrier by improving energy efficiency to make secondary loop refrigeration a more attractive option. | (IV)3. Example bullet 4 - Addresses Issue IV through the improvement in energy efficiency commercial refrigeration equipment. |
| Total PIER 2 Buildings Funding: $6,643,586 | |

| Appendix A - PIER BUILDINGS PROGRAM - Draft Issues, Technical Goals, Examples | | | |
|---|---|---|---|
| **I. Energy Consumption is increasing in hotter, inland areas as new building construction increases in these areas.** | **II. Development of energy efficient products and services does not adequately consider non-energy benefits, such as comfort, productivity, durability, and decreased maintenance costs.** | **III. Building design, construction, and operation of energy features can affect public health and safety.** | **IV. Investment in energy efficiency affects building and housing affordability, value and the state's economy.** |
| ***1. Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue.***<br>• Analyze how electricity pricing (and uncertainty in pricing) will influence building design and customer choices and develop responsive EE design strategies.<br>• Research extent of increase in energy use in these areas in new and existing construction.<br>• Conduct socioeconomic and market functioning research that addresses market barriers to acceptance/adoption of technologies or practices to better focus future research.<br><br>***2. Develop load reduction strategies and technologies.***<br>• Develop EE lighting, controls.<br>- High eff alternatives to incandescent lamps<br>- Improvements to std and compact fluor. lamps<br>- Improved reflectors, downlights<br>• Develop more effective daylighting strategies.<br>• Improve AC equip eff.<br>• Analyze flexduct | ***1. Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue.***<br>• Research how and to what extent non-energy considerations are driving (or can drive) decisions relating to investments in EE.<br><br>***2. Develop metrics to quantitatively predict and measure non-energy benefits for use in energy decision making.***<br>• Develop energy simulation software to evaluate the relationship between energy use and non-energy benefits.<br>• res: relationship between comfort and energy efficiency.<br>• non-residential: benefits of design improvements such as daylighting and natural ventilation<br>• Develop reliable metrics characterizing building occupant comfort and productivity.<br><br>***3. Develop technologies which are both energy efficient and provide non-energy benefits***<br>• Develop lighting and daylighting options (fixtures, ballasts, controls) that are both | ***1. Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue.***<br>• Determine health and safety impacts of current EE design and construction practices.<br>• Identify EE practices and technologies that also enhance health and safety.<br><br>***2. Develop metrics, sensors and controls to measure and improve health, safety, and energy use in buildings.***<br>• Develop metrics, sensors and controls to monitor and control moisture problems related to energy use in buildings.<br>• Develop metrics, sensors and controls to monitor and control indoor air quality problems related to energy use in buildings.<br><br>***3. Develop technologies and strategies to improve energy efficiency and enhance health and safety in buildings.***<br>• Develop EE design and construction techniques that are compatible with strategies to mitigate | ***1. Develop information needed to characterize issue and identify highest value future opportunities to mitigate the issue.***<br>• Research consumer usage patterns relating to energy consuming products (HVAC, lighting, water heating, refrigeration). Identify future research opportunities responsive to customer usage patterns.<br>• Research problems in implementation of the building standards, including installation quality, and compliance practices.<br>• Conduct socioeconomic and market functioning research that addresses market barriers to acceptance/adoption of technologies or practices in order to better focus future research.<br><br>***2. Develop software tools to improve energy efficient product design and implementation.***<br>• Develop energy simulation model to assess heat pump and air conditioner performance in California climates.<br>• Develop and/or improve |

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| longevity problems and develop more durable flexduct or alternatives to flexduct.<br>• Reduce thermal short circuits in walls.<br>• Develop advanced gas-fired cooling equipment.<br>• Develop durable, energy efficient thermal distribution systems.<br>• Develop reliable and energy efficient refrigeration equipment and components.<br>• Develop methods for constructing cool attics.<br>• Develop alternative EE building designs and construction practices.<br>• Develop alternatives to compressor cooling.<br>• Develop natural ventilation strategies integrated in the building design.<br>• Develop technologies and practices for cooling load reduction in existing buildings.<br><br>***3. Develop strategies and technologies to manage loads.***<br>• Develop load shifting options.<br>• Develop improved smart metering technologies and smart controls which provide real-time feedback.<br>• Develop EE designs compatible with distributed heating, cooling, and power generation options. | energy eff. and increase productivity.<br>• Develop technologies that simultaneously provide comfort and EE such as phase change envelopes, electrochromic windows, and active wall systems.<br>• Develop localized ventilation and temperature control of HVAC systems.<br><br>***4. Develop design methods, construction techniques, and strategies which address both energy efficiency and non-energy benefits.***<br>• Develop methods to optimize building design accounting for both energy and non-energy benefits.<br>• Develop methods to incorporate maintenance costs, durability, and reliability into ratings of energy efficient products.<br>• Develop design strategies for optimal thermal distribution systems. | indoor air pollution (ventilation systems, controls, sensors).<br>• Develop EE design and construction techniques that are compatible with strategies to mitigate building moisture problems. | public domain building standards software to include factors such as quality of construction, occupant behavior, etc.<br>• Develop simplified design tools customized to CA climates (may include a developer oriented building economics model).<br>• Develop computer based program which integrates energy efficient design and compliance with standard CAD tools.<br><br>***3. Develop durable and reliable energy efficient technologies to increase building value.***<br>• Develop cost-effective advanced energy efficient technologies such as insulated wall panels, heat pump water heaters, and climate adaptive building envelope components.<br>• Develop downsized EE appliances to match reduced building loads for multi-family applications.<br>• Develop energy efficient steel framing options.<br>• Improve energy efficiency of high energy consuming products in non-residential buildings (refrigeration, office equipment, lighting).<br>• Develop energy efficient products, tools, and practices for existing |

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|---|---|---|---|
| | | | buildings.<br>• Develop waste heat recovery options to reduce life cycle costs of energy consuming products.<br>• Develop designs for improved part load performance of HVAC systems.<br><br>***4. Develop strategies and tools to verify and maintain performance and establish value of investment.***<br>• Develop improved tools and methods to commission new non-residential buildings and re-commission existing bldgs (may include remote monitoring options).<br>• Develop standardized, user-friendly, protocols, specifications, and diagnostic tools for testing and verification of energy performance in homes (verify energy performance, workmanship, IAQ).<br>• Develop tools and techniques for verifying installed insulation levels, envelope sealing, and duct sealing, HVAC and lighting performance.<br><br>***5. Develop systems approaches to maximize value through synergistic building and equipment designs.***<br>• Develop systems design and construction strategies applicable to California climates. |

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| | | | • Develop integrated multi-functional appliances (HVAC/water htg, refrigeration) |